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STRUCTURE, PHENOLOGY, FRUIT YIELD, AND FUTURE PROSPECTS OF SOME PROMINENT WILD EDIBLE PLANT SPECIES OF THE SIKKIM HIMALAYA, INDIA

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ABSTRACT.—In the Himalaya a large variety of plants that grow in forest areas are used as food, and a few of them are exploited on large scale. We discuss six wild tree species of the Sikkim Himalaya that yield edible fruit and that are of great economic value to rural people: *Baccaurea sapida* (Roxb.) Muell.-Arg., *Diploknema butyracea* (Roxb.) Lam., *Elaeagnus latifolia* L., *Eriolobus indica* Schn., *Machilus edulis* King, and *Spondias axillaris* Roxb. These species, which are an important component of forest diversity, are found in low densities, have poor rates of regeneration, and suffer from overexploitation by the local population. All the species have market value and significant potential for value addition. The per-tree fruit yield was fair for each species, and plantation stands could generate high economic returns. It is suggested that a large-scale propagation plan is needed for these species so that farmers could cultivate them, which would reduce the pressure on the wild populations of the forests.

Key words: wild edible plants, structure, regeneration, phenology, fruit yield, marketing.

RESUMEN.—En el Himalaya Sikkim se utilizan como alimento una gran variedad de plantas que crecen en las áreas boscosas, y pocas de ellas se explotan a gran escala. Examinamos seis especies arbóreas silvestres de la región que producen frutas comestibles y que son de gran valor económico para las gentes rurales: *Baccaurea sapida* (Roxb.) Muell.-Arg., *Diploknema butyracea* (Roxb.) Lam., *Elaeagnus latifolia* L., *Eriolobus indica* Schn., *Machilus edulis* King, y *Spondias axillaris* Roxb. Estas especies, que constituyen un componente importante de la diversidad forestal, aparecen en densidades bajas, tienen bajos índices de regeneración, y sufren de sobreexplotación por la gente local. Todas las especies tienen valor en el mercado y un potencial de valor añadido significativo. La producción por árbol es bastante abundante para cada especie, y una plantación podría generar altos beneficios económicos. Sugerimos que se necesita un plan de propagación a gran escala para estas especies de forma que los granjeros pudieran cultivarlas, lo que reduciría la presión sobre las poblaciones silvestres de los bosques.

RÉSUMÉ.—Dans le Sikkim himalayen, une grande diversité de plantes, poussant dans les milieux forestiers, sont utilisées comme plantes alimentaires. Plusieurs sont exploitées à grande échelle. Nous discutons de six espèces d'arbres indigènes de cette région qui donnent des fruits comestibles, soit *Baccaurea sapida* (Roxb.) Muell.-Arg., *Diploknema butyracea* (Roxb.) Lam., *Elaeagnus latifolia* L., *Eriolobus indica* Schn., *Machilus edulis* King et *Spondias axillaris* Roxb. Ce sont des espèces dont la valeur économique est importante pour les populations rurales. Ces es-

pèces forment une part importante de la diversité forestière. Elles se retrouvent à faible densité, possèdent un taux de régénération faible et sont surexploitées par la population locale. Toutes les espèces possèdent une valeur commerciale et un grand potentiel pouvant augmenter leur valeur. Le rendement des récoltes de fruits par arbre était assez bon pour chacune des espèces. Aussi, les plantations pourraient générer un grand profit économique. Aussi, un plan de propagation est nécessaire afin que les agriculteurs puissent cultiver ces espèces. Cela réduirait la pression exercée sur les populations naturelles que l'on trouve en forêt.

INTRODUCTION

People throughout the tropics depend on their indigenous plants for food security and a multitude of everyday products from medicines to fibers. Large numbers of plants are collected from forests and other wild areas to meet subsistence food needs of the people (Arora and Pandey 1996). Such dependence is even greater in the Himalayan region (Samant and Dhar 1997). Wild species producing edible products could play a prominent role in increasing the income of farm households if cultivated or harvested sustainably (Phillips 1993). Some of these plants are rich in nutrients, and their consumption helps to maintain a balanced diet among the rural population (Sundriyal and Sundriyal 2001a). Therefore more attention should be paid to the natural associations, fruit yield and regeneration of potential wild edible species, as many of them often function as keystone species and provide food not only to people, but to many frugivores as well.

In the Sikkim Himalaya, 190 wild plant species used by local communities for food have been screened (Sundriyal 1999; Sundriyal et al. 1998). All of them are collected from wild habitats and to date no effort has been made to cultivate them. We discuss the structure, regeneration, phenology, fruit yield, and marketing of the six most widely used wild plants of the Sikkim Himalaya that produce edible fruits. Due to their poor regeneration in forest habitats, there is an urgent need for them to be propagated under nursery conditions. The study highlights the condition of these species in the forests of Sikkim and provides related information that will be useful for their management.

MATERIALS AND METHODS

The Sikkim Himalaya is the part of Eastern Himalaya, with an elevational range of 300 to 8579 m above msl. Sikkim State has a total area of 7096 km^2, which is just 0.02% of the total area of India. It has a population of 505,505, of which 85% lives in villages. The region is rich in cultural and biological diversity. Lepchas, Bhutias, Limbus, and Nepalese are the main ethnic groups; Nepalese are most numerous. Farmers practice double cropping in the valleys and single cropping at higher elevations (Sundriyal et al. 1994a). In Sikkim, 36% of the area is forested, 15% is under cultivation, 10% is pasture and 25% is barren land. The state has subtropical, temperate and subalpine forests as one goes from lower to higher elevations (Rai and Sundriyal 1997; Sundriyal et al. 1994b, Sundriyal and Sharma 1996). All the forests provide diverse products, such as timber, firewood,

fodder and NTFPs (non-timber forest products). Plants with edible parts are found growing in all the forest stands, are very popular among local people, and a large variety is also brought to markets.

The climate of the area is typically monsoonal. Due to its proximity to the Bay of Bengal, it has high rainfall and humidity, which supports the growth of luxuriant vegetation. Average annual rainfall varies from 1200 mm (at 300 m elevation) to 4500 mm (at 2000 m elevation), and over 80% of the rain comes during the monsoon season (June through September). The average maximum temperature varies from 21° to 35°C while the average minimum temperature varies from 12° to 23°C. The winter (December through February) is generally rainless and cold. The minimum temperature during this period varies from 0°C at higher elevations to 9°C in the valleys, while maximum temperature ranges between 13° to 28°C. October to November is the autumn period; spring falls in March and April. Pleasant weather prevails during these two seasons.

The legal status of forests may be categorized into Reserve Forest (legally protected areas), Khasmahal Forest (forest area designated for the use of villages for meeting their fuel and fodder needs), Community Forest (owned by a village) and Private Forest (owned by an individual farmer). The Sikkim Forest Department manages Reserve and Khasmahal forests and village community or individual farm family manage Community and Private forests.

Description of Selected Wild Edible Plants.—For the present study species were selected with regard to their potential in terms of their importance to local population; high anthropogenic pressure in the natural habitats; high local demand for the fruits; market value; dearth of information available about their structure, phenology, regeneration and growth; and the possibility of incorporating the propagation of these species in traditional agroforestry systems. Six wild edible species met these criteria and were selected for detailed study: *Baccaurea sapida* (Roxb.) Muell.-Arg., *Diploknema butyracea* (Roxb.) Lam., *Elaeagnus latifolia* L., *Eriolobus indica* Schn., *Machilus edulis* King, and *Spondias axillaris* Roxb. All are trees except *Elaeagnus latifolia,* which is a liana (woody climber).

Baccaurea sapida (syn. *B. ramiflora* Lour., Euphorbiaceae; local name: *kusum* 'sapida') is a small to medium size (up to 10 m height) semi-evergreen tree that grows in the subtropical forests at elevations of 500–1500 m above msl. The yellowish fruits are available from May to August.

Diploknema butyracea (syn. *Bassia butyracea* Roxb., *Aesandra butyracea* (Roxb.) Baehni, Sapotaceae; local name: *chiuree* 'Indian butter tree') is a tree of nearly 15 m height, that grows at elevations of 300–1300 m above msl. The fruits are scented and pulp is juicy and sweet.

Elaeagnus latifolia (syn. *Elaeagnus conferta* Roxb., Elaeagnaceae; local name: *muslendi* 'bastard oleaster') is a large evergreen liana that grows at lower elevations in the Sikkim Himalaya. Fruits are collected during March and April and are commonly available in the markets at that time.

Eriolobus indica (Rosaceae; local name: *mehal* 'Indian crabapple') is a deciduous tree (9–12 m height) of the lower temperate zone (900–1800 m above msl). Fruits are available July–September and eaten fresh or processed into a form of pickle.

An extract of the fruit is made into *chuk,* a medicine valued for relieving stomach pain.

Machilus edulis (syn. *Persea fructifera* Kost., Lauraceae; local name: *pumsi*) is an evergreen tree of about 20–30 m height that grows in natural forests at elevations above 1700 m. It is considered to be a local variety of avocado (*Persea americana*). Fruits are commonly found in markets during December to March, and the outer fleshy pulp that comes out attached with the skin is scooped out and eaten.

Spondias axillaris (syn. *S. acuminata* (L.f.) Kurz., *Choerospondias axillaris* (Roxb.) Burtt. & Hill, Anacardiaceae; local name: *lapsi* 'hog-plum') is a tree that can reach a height of 35 m. It commonly grows in lower hill forests. The ripened fruits are eaten raw. The fruits that are sold at a semiripe stage are pickled, which gives them a shelf life of up to 3–5 years.

METHODS

Vegetation Structure Analysis and Regeneration.—In order to analyze the vegetation structure and regeneration for the six selected species, eight forests were chosen for detailed study based on the preliminary surveys done for areas that are frequented by forest dwellers. The vegetation was sampled with 10 × 10-m quadrats. Depending upon the area of each of the forests, between 30 and 40 quadrats were examined (Sundriyal 1999). All tree species and indviduals growing in a quadrat were listed and their cbh (circumference at breast height) was noted. Woody plants with >32.4-cm cbh were counted as trees (Sundriyal et al. 1994b; Sundriyal and Sharma 1996). The frequency, density, abundance, and basal cover (ground area covered by each species) were calculated following the method given by Curtis and Cottam (1956). To measure the dominance of each tree species, the Importance Value Index (IVI) was calculated as a sum of relative frequency, relative density and relative dominance (Mueller-Dombois and Ellenberg 1974). For each stand, the species with the highest IVI was considered most dominant. The A/F (abundance/frequency) ratio was calculated to interpret the distribution pattern of the species; a value <0.025 shows regular distribution, between 0.025–0.05 shows random distribution, and >0.05 shows contagious distribution of the species in the forest stand (Saxena and Singh 1982).

The regeneration of all species was assessed from 20 randomly selected quadrats of 10 × 10-m size in each forest stand. All plants with <32.4-cm cbh consisting of saplings and seedlings of woody species were considered to be regenerating individuals (Sundriyal et al. 1994b; Sundriyal and Sharma 1996), and density for all species was noted that also included wild edible plants in each stand.

Phenological Investigation.—Study of the phenological stages of a species provides information on its functional aspects: growth of buds, leaf fall and leafing out, anthesis, fruiting and seed dispersal in relation to months, season or years that describes seasonal aspects of ecological phenomenon. Understanding phenology is very important for optimal species management under forest conditions. The phenological investigation for each species was conducted in at least two stands. For each species, 5–8 individual trees were marked at each stand to study the phenological observations on leaf fall, leaf bud formation and flushing, flower bud

formation and anthesis, fruit formation and maturation, and seed dispersal (Ralhan et al. 1985; Sundriyal 1990).

Fruit Yield.—Fruit yields were determined by harvesting and recorded individually by tree. For all the species, individuals of different girth classes and heights were marked at different locations well before fruit bearing. Tree girth at breast height, and height (with the help of a bamboo stick) was measured for all selected individuals. Efforts were made to harvest almost all the fruits of small trees. For big trees it was not possible to harvest all the fruits. Therefore, the uncollected fruits were counted visually and converted to biomass value based on the harvested fruits. This method accounts for nearly 70–80% of total fruit yield. Per-tree fruit yield was plotted against tree circumference at breast height (cbh) for the harvested individuals. Regression equations were developed to assess the relationship between fruit productivity and tree girth.

Marketing of Selected Species.—Three prominent markets of Sikkim State, namely Gangtok, Namchi, and Singtam, were surveyed every other week for one year. For each fruit type, data about its period of availability, number of retailers involved per week in its trade, quantity sold, and gross income to the retailer from its sale.

RESULTS

Characteristics of Forest Stands and Status of Wild Edible Plants.—Table 1 provides details of all the sampled forest stands ranging from elevations of 400–2600 m in the Sikkim Himalaya. Of eight stands sampled, three are in the Reserve Forest, one is in Khasmahal forest, three are in Community Forest and one is in the Private Forest. The Reserve Forest areas generally do not suffer any severe anthropogenic pressure from fuel and timber collection. Field visits and discussion with local people revealed, however, that people do collect fodder and various other NTFPs, which also include wild edible plants. Khasmahal Forests are supposed to fulfill villagers' need for fuel, fodder, and timber, and thus bear maximum pressure. The Community and Private Forests generally have higher proportions of the species preferred for their subsistence value. The Reserve Forests (Stands I, II, VIII) maintain high diversity of species with high density and basal cover, which is expected in view of low anthropogenic pressure in these forests. Stand II was in the most inaccessible area. Even so, people collect wild edible plants there. The Khasmahal Forest (Stand VII) showed low density and basal cover due to high anthropogenic pressure. The Community Forests (Stands IV, V, VI) were also in fairly good condition, though the Private forest (Stand III) was highly exploited due to individual family demands. The presence and absence of different species along with their common names is presented in Table 2. Altogether 143 tree species were identified. Stand II had the most species (30), closely followed by Stand VIII (29 species). Data concerning the phytosociology of each stand discussed below are presented in Table 3.

Stand I. This forest stand occurs at elevations of 400–700 m, and represents a typical subtropical forest of the Eastern Himalayan region. According to Forest Department records the forest stand was originally dominated by *Shorea robusta;*

TABLE 1.—Characteristics of the forest stands/sites sampled for vegetation structure and regeneration of selected wild edible species.

Site characteristics	Forest stands/Sites							
	I	II	III	IV	V	VI	VII	VIII
Location	Mamkhola	Raileykhola	Chhota-Sing-tam	Samdung	Central Pan-dam	Yuksam	Pangthang (lower)	Tendong-Ti-fintop
District	Darjeeling	Darjeeling	South Sikkim	East Sikkim	East Sikkim	West Sikkim	East Sikkim	South Sikkim
Elevation range	400–700 m	450–900 m	860–1050 m	800–1400 m	1200–1500 m	1200–1600 m	1500–1900 m	1700–2600 m
Forest category	Reserve	Reserve	Private	Community	Community	Community	Khasmahal	Reserve
Total number of tree species in stand	23	30	23	16	23	12	15	29
Total no. of wild edible species in stand*	7	7	5	4	4	3	3	9
Dominant tree species	*T. grandis–S. robusta*	*C. indica–S. robusta*	*S. wallichii–Albizia*	*A. nepalensis–E. indica*	*F. roxburghii–S. axillaris*	*C. tribuloides–E. indica*	*E. acuminata–S. theifolia*	*O. lamellosa–C. tribuloides*
Standing trees (ha^{-1})	711	600	280	393	495	420	350	715
Basal area (m^2ha^{-1})	43.52	48.54	19.45	21.66	27.70	51.64	37.75	91.27
Biotic pressure**	Medium	Low-medium	High	High	Selective	Selective	Very high	Low
Total density of all wild edible species (individuals ha^{-1})	180	150	100	105	135	69	55	155
Basal area of all wild edible species (m^2ha^{-1})	9.89	11.80	3.35	4.11	7.35	19.90	16.15	17.12
Total stand regeneration (ha^{-1})	NR	3820	1655	1710	2060	2786	3138	4700
Regenerating of wild edible plants (ha^{-1})	NR	1560	725	695	730	765	503	230

* Details of the species is provided in Table 2; NR—data not recorded.

** "Biotic pressure" is a qualitative assessment based on field observations; it is based on the number of trees cut and lopped and the quantity of NTFPs and fodder collected in each forest stand.

TABLE 2.—Presence (+) of tree species and wild edible plants at different forest stands in the Sikkim Himalaya.

Species	Local name*	Forest stands							
		I	II	III	IV	V	VI	VII	VIII
Acer campbellii Hk.f. & T.	kapase	−	−	−	−	−	+	+	+
Acer oblongum Wall.	phirphire	−	+	−	−	−	−	−	+
Albizia procera (Roxb.) Benth.	siris	−	−	+	+	−	−	+	−
Albizia stipulata Boiv.	rato-siris	−	−	−	−	+	−	−	−
Alnus nepalensis Don.	utish	−	−	−	+	−	−	+	−
Amoora wallichii King.	lahsune	+	+	−	−	−	−	−	−
Artocarpus lakoocha (Roxb.)	badar	−	+	−	−	−	−	−	−
Artocarpus sp.	kathal	−	−	+	−	−	−	−	−
Baccaurea sapida (Roxb.) Muell.-Arg.	kusum	+	+	−	−	−	−	−	−
Bambusa nutans (Wall. ex Munro)	choya bans	−	+	−	+	+	−	−	−
Bambusa sp.	nibabans	−	−	−	−	+	−	−	−
Bauhinia variegata L.	tanki	+	+	−	−	−	−	−	−
Beilschmiedia roxburghiana Nees.	tarsing	−	−	−	−	−	−	+	+
Betula alnoides Buch.-Ham.	saur	−	−	+	−	−	−	−	−
Betula cylindrostachys Wall.	saur	−	−	−	−	−	−	−	+
Bombax malabaricum DC.	semal	−	−	−	−	+	−	−	−
Brassaiopsis mitis Clarke	chuletro	−	−	+	+	+	−	−	−
Bridelia retusa (L.) Spreng.	gayo	+	−	−	−	−	−	−	−
Callicarpa arborea Roxb.	guyilo	+	−	−	−	−	−	−	−
Casearia tomentosa Roxb.	barkule	−	+	−	−	−	−	−	−
Castanopsis indica A. DC.	dhalne katus	+	+	+	−	+	+	−	−
Castanopsis tribuloides A. DC.	musure katus	−	−	+	−	−	−	+	+
Celtis tetrandra Wall.	khari	−	−	−	−	−	−	−	+
Cinnamomum impressinervium Meissn.	sisi	−	−	−	−	−	−	−	+
Cryptomeria japonica Don.	dhupi	−	−	+	+	−	−	−	−
Dendrocalamus sikkimensis Gamble.	bhalubans	−	−	−	−	+	−	−	−
Dendrocalamus strictus (Roxb.) Nees.	bans	−	−	−	+	−	−	−	−
Diploknema butyracea (Roxb.) Lam.	chiuree	−	+	+	−	−	−	−	−
Duabanga grandiflora (Roxb. ex DC)	lampatey	−	+	−	−	−	−	−	−

TABLE 2—(continued)

Species	Local name*	Forest stands							
		I	II	III	IV	V	VI	VII	VIII
Echinocarpus dasycarpus Benth.	gobrey	−	−	−	−	−	−	−	+
Elaeagnus latifolia Linn.	muslendi	−	−	+	−	−	−	−	−
Elaeocarpus sikkimensis Mast.	bhadrasey	−	−	−	−	−	−	+	+
Emblica officinalis (Gaerth.)	amla	+	+	−	−	−	−	−	−
Endospermum chinense Benth.	setikath	−	−	−	−	−	−	+	+
Engelhardtia spicata Bl.	mahua	−	+	+	−	+	+	−	+
Eriolobus indica Schn.	mehal, likung	−	−	−	+	−	+	−	−
Erythrina sp.	phaledo	−	−	−	+	−	−	−	−
Eurya acuminata DC.	jhingni	−	−	−	−	−	+	+	+
Evodia fraxinifolia HK.f.	khanakpa	−	−	−	−	−	−	+	+
Ficus bengalensis L.	bar	−	−	−	−	+	−	−	−
Ficus benjamina L.	kabra	−	−	+	−	+	−	−	−
Ficus cunia Ham.	khaniu	−	−	−	+	+	−	−	−
Ficus elastica Roxb.	labar	−	+	−	+	−	−	−	−
Ficus hirta Vahl.	khasre	−	−	−	−	+	−	−	−
Ficus hispida L.	khasrey	−	−	+	−	−	−	−	−
Ficus hookerii Corner	nebara	−	−	−	+	−	−	−	−
Ficus nemoralis Wall.	dudhilo	−	−	−	−	+	−	−	−
Ficus roxburghii Roxb.	nebara	−	−	+	+	+	−	−	−
Gmelina arborea L.	khameri	−	+	−	−	−	−	−	−
Gynocardia odorata R. Br.	gante	+	−	−	−	−	−	−	−
Gynocardia odorata R. Br.	gantey	−	+	+	−	−	−	−	−
Ilex sikkimensis Hk. f.	lisey	−	−	−	−	−	−	−	+
Juglans regia L.	okhar	−	−	−	−	−	+	−	+
Leucosceptrum canum Sm.	ghurpis	−	−	+	−	+	−	−	+
Litsaea citrata Bl.	siltimur	−	−	+	−	+	−	−	−
Litsaea oblonga Wall.	kalipahenle	−	−	−	−	−	−	−	+
Litsaea polyantha Juss.	kutmero	−	−	+	−	+	−	−	−
Lyonia ovalifolia (Wall.)	angeri	−	−	−	−	−	+	−	+
Macaranga pustulata King.	malata	+	−	−	−	+	+	−	+

TABLE 2—(continued)

Species	Local name*	Forest stands							
		I	II	III	IV	V	VI	VII	VIII
Macaranga sp.	seto-malata								
Machilus edulis King.	lapche kawlo,	−	+	−	−	−	−	−	−
	pumsi, phun-chey	−	−	−	−	−	+	+	+
Machilus gammieana King.	kawlo	−	+	−	−	−	−	+	+
Machilus odoratissima Wall.	lali-kawlo	−	−	−	−	−	−	+	−
Machilus sp.	bhaisi kawlo	+	−	−	−	−	−	−	−
Mallotus philippinensis (Muell.-Arg.)	sindure	+	+	−	−	−	−	−	−
Mangifera indica Wall.	anp	−	−	+	−	−	−	−	−
Mangifera sylvatica (Roxb.)	chuche anp	+	−	−	−	−	−	−	−
Measa chisia D. Don.	bilaune	−	−	+	−	−	+	−	+
Melia azadirachta L.	bakain	−	−	−	+	−	−	−	−
Meliosma thomsonii King. ex Brandis.	dabdabe	−	+	−	−	−	−	−	−
Michelia excelsa Bl.	chanp	−	−	−	−	−	−	+	+
Michelia lanuginosa Wall.	tite-chanp	−	−	−	−	−	−	+	−
Mimosa himalayana Gamble.	arare	+	−	−	−	−	−	−	−
Morus laevigata (Wall.)	kimbu	+	+	+	+	−	−	−	−
Myrica sapida Wall.	kaphal	−	−	−	−	−	−	−	+
Nyssa sessiliflora HK.	lekh chilaune	−	−	−	−	−	−	−	+
Oroxylum indicum Vent.	totala	−	+	−	−	−	−	−	−
Pandanus L.	tarika	+	+	−	−	−	−	−	−
Prunus cerasoides D. Don.	paiyun	−	−	−	−	−	+	−	−
Prunus nepalensis Koch.	arupate	−	−	−	−	−	−	+	−
Prunus persica Batsch.	aru	−	−	−	+	−	−	−	−
Psidium guajava L.	ambak	−	−	+	−	−	−	−	−
Pyrus pashia (Buch.-Hamex Don.)	naspati	−	−	+	+	−	−	−	−
Quercus fenestrata Roxb.	arkholo	−	−	−	−	−	−	−	+
Quercus lamellosa Sm.	book	−	−	−	−	−	−	−	+
Quercus sp.	—	−	−	−	−	−	−	−	+

TABLE 2—(continued)

Species	Local name*	Forest stands							
		I	II	III	IV	V	VI	VII	VIII
Rhododendron arboreum Sm.	lali gurans	−	−	−	−	−	−	−	+
Rhus succedanea L.	bhalayo	−	−	+	+	−	+	+	−
Salmalia malabarica Schott.	semul	−	−	−	−	+	−	−	−
Schima wallichii (DC.) Karth	chilaune	+	+	+	−	+	−	−	−
Shorea robusta (Gaernt. f.)	sakuwa	+	+	−	−	−	−	−	−
Spondias axillaris Roxb.	lapsi, silet-kung, lumsee	−	−	+	−	+	−	−	−
Stereospermum suaveolans DC.	parari	−	+	−	−	−	−	−	−
Symplocos sumuntia Ham.	kholmein	−	−	−	−	−	+	+	+
Symplocos theifolia D. Don	kharane	−	−	−	−	−	+	+	+
Tectona grandis (L. f.)	sagon	+	−	−	−	−	−	−	−
Terminalia belerica (Gaertn.) Roxb.	barrah	−	−	+	−	−	−	−	−
Terminalia myriocarpa (Muell.-Arg.)	panisaj	+	−	−	−	−	−	−	−
Terminalia tomentosa Bedd.	pakhasaj	−	−	+	−	−	−	−	−
Toona cilliata M. Roem.	tuni	−	−	−	−	+	−	−	−
Viburnum cordifolium Wall.	asare	−	−	−	−	−	+	+	−
Walsura tubulata Hiern.	phalame	−	−	−	−	−	+	−	+
Zanthoxylum budrunga Wall.	siltimur	−	−	−	−	+	−	−	−
Unidentified	amphi	−	−	−	+	−	−	−	−
Unidentified	badari	−	+	−	−	−	−	−	−
Unidentified	bakhain	−	−	−	+	−	−	−	−
Unidentified	dayar	+	−	−	−	−	−	−	−
Unidentified	kalikath	+	−	−	−	−	−	−	−
Unidentified	kamlo	−	−	−	−	+	−	−	−
Unidentified	khankar	−	+	−	−	−	−	−	−
Unidentified	kheari	−	−	+	−	−	−	−	−
Unidentified	mahina	−	+	−	−	−	−	−	−
Unidentified	mahony	−	−	−	−	+	−	−	−
Unidentified	pailey	+	−	−	−	−	−	−	−
Unidentified	pilpile	+	−	−	−	−	−	−	−

* First (or only) name listed is Nepali, second is Lepcha, and third is Bhutia.

after selective felling during the early 1980s, however, the stand was replanted with *Tectona grandis* (IVI 40.12) as well as *S. robusta* (IVI 39.87). Other important tree species of the stand were *Schima wallichii, Dysoxylum binectariferum, Baccaurea sapida, Mallotus phillipensis* and *Terminalia myriocarpa.* The forest stand had a density of 711 trees ha^{-1} and a total basal cover of 43.52 m^2ha^{-1}. Edible fruits of *B. sapida, Emblica officinalis,* and *Mangifera sylvatica* were collected; exploitation of two other wild edible types, *Morus laevigata* and *Pandanus* sp., was insignificant. *B. sapida* showed an even distribution in the stand. All wild edible species together contributed 25.32% of the total stand density, 22.73% of the total basal cover and 25% of the total IVI. *B. sapida* represented 26% of the total density of all wild edible species. Field observations revealed that this species is not only exploited for fruit collection but a significant number of individual trees are either cut or lopped for firewood as well.

Stand II. The Raileykhola forest was studied for the structure and associates of *Diploknema butyracea* and *Baccaurea sapida.* This stand falls in the remotest areas of Kalimpong forest range, and therefore is less affected by fuel and fodder collection. The forest is dominated by *Castanopsis indica* and *Shorea robusta,* both of which occur at high density, basal cover, and IVI. Altogether the wild edible species in the forest contributed 25% of the total stand density and 24.31% of the total stand basal area. Only *D. butyracea* contributed 7.5% of the total density and 11% of the total basal cover of the stand. The site had big individuals of *D. butyracea* of over 1.0-m girth. Among other edible species, the density of *B. sapida* contributed 11% of the total stand density and 3% of the total basal cover. *Bambusa nutans,* which is an edible species, accounts for 7% of the density and 17% of the total basal cover. These three wild edible species are mainly collected for selling in the market. The other important wild edible species in the stand were *Emblica officinalis* and *Artocarpus lakoocha. Bambusa nutans* (IVI 28.55), *D. butyracea* (IVI 25.49), *B. sapida* (IVI 22.73), *Artocarpus lakoocha* (IVI 12.14) and *E. officinalis* (IVI 8.63) contributed a total IVI of 97.54 (nearly one-third of total IVI), which shows that the present forest stand is an important habitat for wild plants of food value.

Stand III. The stand falls in the category of Private Forest, and *Elaeagnus latifolia* was major wild edible species in this stand. Fruits of *E. latifolia* are collected in large quantities and sold in the markets. The site also supports a few other wild edible species, viz. *Diploknema butyracea, Terminalia bellerica* and *Spondias axillaris.* The five wild edible species of the stand had 30.71, 17.22 and 25.97% of the total stand density, basal cover and IVI, respectively. *E. latifolia* and *D. butyracea* contributed more than 50% density of all wild edible species. The stand was dominated by *Schima wallichii* that is used for firewood. *Albizia procera* was the subdominant species, though its density, basal cover and IVI was much less than *S. wallichii.* The total tree density and basal cover of this stand was minimum among all the studied forest stands.

Stand IV. This was a Community stand and *Alnus nepalensis* had naturalized at different locations and showed maximum density (120 individual ha^{-1}), basal cover (7.06 m^2ha^{-1}) and IVI (77.40). *Pyrus pashia, Ficus* sp., *Cryptomeria japonica, Prunus persica* were planted species at this site. The wild edible species *Eriolobus indica* was present and maintained for commercial purposes, though in low quantities. *E. indica* contributed 12% of the total density and 13% of the total basal

cover of the stand. All edible species contributed 27% and 19% of the total stand density and basal cover, respectively.

Stand V. In this Community forest stand most of the species are of great economic importance. *Spondias axillaris* (IVI 36.17) and *Ficus roxburghii* (IVI 35.51) are the dominant tree species. The former is kept for edible fruits while the latter for its high fodder value. The bamboo species were also found in the stand, which are essential for various household activities. The forest had a total number of 23 tree species with a total stand density of 495 trees ha^{-1} and a total basal cover of 28.0 m^2ha^{-1}. The four wild edible species in the stand had a combined density of 135 trees ha^{-1}, with *S. axillaris* contributing more than 40% of it. The four types contribute 26.53% of the total basal cover and 28% of the total IVI. Fruits of *S. axillaris* were collected and sold in large quantities.

Stand VI. This Community Forest was dominated by *Castanopsis tribuloides* among nineteen other tree species. The species composition in this site is similar to that of undisturbed stands. The stand contained three wild edible species, viz. *Eriolobus indica, Machilus edulis,* and *Juglans regia.* The overall density of the stand was 420 trees ha^{-1} with a total basal area of 51.64 m^2ha^{-1}. The wild edible species contributed 16.43% to total stand density, 38.54% to total basal area and 21.21% to total IVI.

Stand VII. This forest occurs at elevations between 1500 and 1900 m and falls under Khasmahal Forest category. Due to heavy anthropogenic pressure the site was dominated by secondary species, mainly *Eurya acuminata* and *Symplocos theifolia. Machilus edulis,* which produces edible fruits, was an important species at the site. The stand had a total basal cover of 37.75 m^2ha^{-1} with a tree density of 350 individuals ha^{-1}. *M. edulis* contributed 34% of total basal cover with 25 trees ha^{-1}. The field observations showed that the stand was frequently visited by fruit collectors who gathered fruits of *Elaeocarpus sikkimensis* and *Castanopsis tribuloides,* in addition to those of *Machilus edulis,* for sale in the market. These three species together had a total density of 55 trees ha^{-1}, a total basal cover of 16.15 m^2ha^{-1} and a total IVI of 79.18 in the stand.

Stand VIII. The forest falls in the Reserve Forest category and represents a typical temperate forest community for the Sikkim Himalaya. *Quercus lamellosa* and *Castanopsis tribuloides* were dominant species of the stand. *Machilus edulis, Rhododendron arboreum, Lyonia ovalifolia,* and *Symplocos theifolia* were other associated species of the stand. Besides collection of fruits of *M. edulis,* residents also collect small quantities of *Cinnamomum impressinervium, Castanopsis tribuloides, Myrica sapida,* and *Evodia fraxinifolia* fruits. All the wild edible species contributed 21.68% of total density and 20.49% of total IVI of the stand. The total density of the stand was 715 trees ha^{-1} and the total basal cover 91.27 m^2ha^{-1}, which was maximum among all the studied stands. *M. edulis* contributed 8% of total density and 6% of total basal cover in the stand.

Species Regeneration.—Among the seven stands examined in the regeneration study, the highest number of seedling and saplings was recorded at Stand VIII (4700 individuals ha^{-1}), followed by Stand II (3820 individuals ha^{-1}). Both these stands were in Reserve Forests. The total regeneration was recorded as 3043 individuals ha^{-1} for Stand VII, which is a Khasmahal forest. In Community and Private forests

the regeneration was relatively low (Tables 1, 3). Altogether a total of 80 tree species have been recorded regenerating across all the sampled sites. For each stand, 21 out of 30 trees species at Stand II, 18 out of 23 tree species at Stand III, 18 out of 29 species at Stand VIII, and all tree species of Stands IV, VI and VII were found regenerating. Total number of wild edible species regenerating also vary at different stands, and the number was recorded as 9, 5, 5, 5, 5, 6 and 7 at Stands II to VIII, respectively. The contribution of wild edible plants to total regeneration was very high (65%) at Stand III, and fairly good (35%) at Stands IV and V, though it was low in Reserve Forest stands. Discussion with members of the local community revealed that species of low economic value are sometimes uprooted from the Private and Community forests, and therefore many such species do not become mature trees. It can be said that in the Reserve Forests all species are allowed to regenerate, while in Private and Community Forests less valued species are more likely to be removed.

Phenology.—Major phenological events—leaf falling, flushing, flowering, fruiting, and seed dispersal—were recorded for the six species in this study (Table 4).

Leaf fall and flushing. The periodicity of leaf fall and leafing for various species slightly varies at different stands. For the two deciduous trees, leaf fall started in November–December for *Spondias axillaris* and April–May for *Diploknema butyracea.* Flushing was recorded during March–June for various species. Evergreen species do not show any marked leaf fall, and flushing was recorded in small amounts throughout the year. The active leaf growth period was nearly six weeks for *Baccaurea sapida,* eight weeks for *Eriolobus indica,* and four weeks for *S. axillaris* and *D. butyracea.*

Flowering. Flowering was concentrated in a short period of about three weeks in *Eriolobus indica,* six weeks in *Baccaurea sapida,* and seven to eight weeks in other species. Flowering comes to an end in January for *Diploknema butyracea* and *Elaeagnus latifolia,* in April for *B. sapida* and *Eriolobus indica,* in May for *Machilus edulis,* and in June for *Spondias axillaris.*

Fruiting. Completion of flower phase is followed by fruit development. The period of fruit development for different species varied from eight weeks for *Elaeagnus latifolia* and *Diploknema butyracea* and eight to ten weeks for *Baccaurea sapida.* This period was relatively longer for *Eriolobus indica,* and *Spondias axillaris* (16–20 weeks) and more than 20 weeks for *Machilus edulis.* Among all species, fruits of *M. edulis* were bigger in size, followed by *E. indica.* Fruits of *S. axillaris* were smallest in size among the six studied species. Mature fruits were available in April–May for *D. butyracea* and *E. latifolia,* in July–August for *B. sapida,* in October–November for *E. indica* and *S. axillaris,* and December–January for *M. edulis.* Large quantities of fruits were available in the local markets during the period of availability of different fruits.

Fruit Yield.—The fruit yield per tree for six species was measured in different girth classes (age) (Figure 1). All the species varied in their ability to produce fruit (Table 5). *Diploknema butyracea* fruits were harvested from a girth class of 80 to 165 cm and the fruit yield varied from 5 to 155 kg per tree. Tree height, canopy, number of branches and average number of fruits per tree increases with the girth class size, which has a positive correlation with the total fruit yield ($p<0.05$). For

TABLE 3.—Vegetation structure of some wild edible tree species and regeneration status (seedlings + saplings) at different forest stands in the Sikkim Himalaya.

Species[a]	Density (ha^{-1})	A/F[b] ratio	Total basal area (m^2ha^{-1})	IVI[c]	Regeneration (ha^{-1})[d]
Stand I: Mamkhola					
Amoora wallichii	47.00	0.11	1.990	14.64	NR
Baccaurea sapida	47.00	0.02	1.620	19.50	NR
Bauhinia variegata	20.00	0.05	0.800	8.17	NR
Bridelia retusa	13.00	0.07	0.436	5.16	NR
Callicarpa arborea	20.00	0.05	0.590	7.69	NR
Castanopsis indica	33.00	0.04	2.200	14.50	NR
Emblica officinalis	20.00	0.05	1.440	9.64	NR
**Gynocardia odorata*	13.00	0.07	0.856	6.13	NR
Macaranga pustulata	20.00	0.05	1.590	9.98	NR
Machilus sp.	13.00	0.08	1.300	7.15	NR
Mallotus philippinensis	33.00	0.05	0.570	10.75	NR
Mangifera sylvatica	27.00	0.01	3.240	14.71	NR
Mimosa himalayana	6.00	0.14	0.119	2.45	NR
**Morus laevigata*	27.00	0.07	1.000	9.57	NR
**Pandanus* sp.	20.00	0.05	0.260	6.93	NR
Schima wallichii	53.00	0.03	2.300	19.82	NR
Shorea robusta	80.00	0.03	8.400	39.87	NR
Tectona grandis	100.00	0.04	8.100	40.12	NR
Terminalia myriocarpa	33.00	0.05	2.600	15.42	NR
Unidentified-1	13.00	0.08	0.100	4.39	NR
Unidentified-2	13.00	0.08	0.990	6.43	NR
Unidentified-3	13.00	0.08	0.819	6.04	NR
Unidentified-4	47.00	0.02	2.200	19.90	NR
Stand II: Raileykhola					
Acer oblongum	5.00	0.21	0.094	2.32	75
Amoora wallichii	5.00	0.16	0.330	2.82	—
Artocarpus lakoocha	15.00	0.31	4.080	12.14	50
Baccaurea sapida	65.00	0.05	1.320	22.73	505
Bambusa nutans	45.00	0.20	8.380	28.55	540
**Bauhinia variegata*	5.00	0.22	0.150	2.45	25
Casearia tomentosa	5.00	0.24	0.140	2.42	115
Castanopsis indica	8.00	0.23	9.720	47.64	520
Diploknema butyracea	45.00	0.07	5.590	25.49	—
Duabanga grandiflora	20.00	0.20	1.190	8.39	95
Emblica officinalis	20.00	0.09	0.660	8.63	100
Engelhardtia spicata	10.00	0.12	0.561	5.44	110
Ficus sp.	5.00	0.18	0.100	2.35	—
Gmelina arborea	10.00	0.10	0.160	4.63	70
Gynocardia odorata	5.00	0.22	0.250	2.65	105
Macaranga sp.	10.00	0.10	0.320	4.95	
Machilus gammieana	10.00	0.11	1.220	6.79	130
Mallotus philippinensis	20.00	0.08	0.350	7.99	110
Meliosma thomsonii	5.00	0.20	0.270	2.70	35
Morus laevigata	5.00	0.10	0.130	3.72	25
Oroxylum indicum	5.00	0.19	0.090	2.33	65
**Pandanus* sp.	5.00	0.21	0.040	2.22	20
Schima wallichii	50.00	0.40	2.410	22.46	720
Shorea robusta	70.00	0.31	9.870	35.77	—
Stereospermum suaveolans	10.00	0.13	0.230	4.77	—

TABLE 3—(continued)

Species[a]	Density (ha^{-1})	A/F[b] ratio	Total basal area (m^2ha^{-1})	IVI[c]	Regeneration (ha^{-1})[d]
Unidentified (2 species)	50.00	0.11	0.920	18.12	—
Unidentified (Badari)	10.00	0.10	0.19	4.69	—
Unidentified (Khankar)	5.00	0.20	0.080	2.30	—
Unidentified (Mahina)	5.00	0.17	0.150	2.46	—
Unidentified (4 species)	—	—	—	—	405
Stand III: Chhota-Singtam					
Albizia procera	20.00	0.05	2.217	25.32	5
Artocarpus sp.	5.00	0.22	0.012	9.53	—
Betula alnoides	20.00	0.40	2.058	16.27	—
Brassaiopsis mitis	10.00	0.20	0.698	8.37	65
Castanopsis indica	—	—	—	—	5
Castanopsis tribuloides	—	—	—	—	15
Cryptomeria japonica	5.00	0.20	0.779	7.49	—
Diploknema butyracea	5.00	0.20	0.031	3.64	—
Elaeagnus latifolia	45.00	0.11	0.221	21.64	610
Engelhardtia spicata	5.00	0.20	0.308	5.06	5
**Ficus benjamina*	15.00	0.07	1.357	17.42	—
Ficus hispida	10.00	0.10	0.089	7.42	30
**Ficus roxburghii*	5.00	0.22	0.129	4.14	—
Gynocardia odorata	—	—	—	—	285
Leucosceptrum canum	—	—	—	—	20
Litsaea citrata	5.00	0.20	0.099	3.99	—
Litsaea polyantha	5.00	0.20	0.134	4.17	—
Mangifera indica	5.00	0.24	0.652	6.83	—
Measa chisia	—	—	—	—	275
Morus laevigata	—	—	—	—	15
Psidium guajava	5.00	0.20	0.049	3.73	—
Pyrus pashia	5.00	0.21	0.281	4.93	—
Rhus succedanea	20.00	0.09	0.382	13.72	—
Schima wallichii	55.00	0.04	6.450	99.92	65
Spondias axillaris	5.00	0.24	0.153	4.27	—
Terminalia belerica	5.00	0.20	0.472	5.91	—
Terminalia tomentosa	15.00	0.06	1.316	17.21	—
Unidentified (Kheari)	5.00	0.20	0.242	4.72	—
Unidentified (6 species)	—	—	—	—	270
Stand IV: Samdung					
Albizia sp.	21.00	0.05	1.132	16.27	140
Alnus nepalensis	120.00	0.12	7.060	77.40	400
Brassaiopsis mitis	21.00	0.05	0.748	14.56	110
Bambusa nutans	—	—	—	—	95
Cryptomeria japonica	10.00	0.10	0.191	6.27	20
Dendrocalamus strictus	14.00	0.20	1.450	13.10	—
Eriolobus indica	47.00	0.02	2.720	41.61	180
Erythrina sp.	16.00	0.20	0.880	10.99	95
Ficus cunia	20.00	0.05	1.109	15.92	105
Ficus elastica	20.00	0.10	2.270	21.28	45
Ficus hookerii	18.00	0.04	0.652	16.16	—
Ficus roxburghii	—	—	—	—	110
Melia azadirachta	12.00	0.20	0.263	7.12	—
**Morus laevigata*	10.00	0.05	0.210	6.37	95

TABLE 3—(continued)

Species[a]	Density (ha^{-1})	A/F[b] ratio	Total basal area (m^2ha^{-1})	IVI[c]	Regeneration (ha^{-1})[d]
Prunus persica	10.00	0.10	0.144	6.05	60
Pyrus pashia	20.00	0.10	0.382	12.56	50
Rhus succedanea	23.00	0.03	1.660	22.08	115
Unidentified	11.00	0.05	0.815	12.26	15
Unidentified	—	—	—	—	75
Stand V: Central Pandam					
Albizia stipulata	22.00	0.22	1.260	11.16	70
Bambusa nutans	15.00	0.60	1.452	9.54	—
Bambusa sp.	35.00	0.15	2.988	21.69	—
Bombax malabaricum	10.00	0.41	1.203	7.63	—
Brassaiopsis mitis	30.00	0.04	0.725	17.03	75
Castanopsis indica	10.00	0.10	0.928	7.94	65
Dendrocalamus sikkimensis	17.00	0.02	3.137	17.05	270
Engelhardtia spicata	30.00	0.05	1.296	17.22	35
Ficus bengalensis	10.00	0.40	1.386	8.29	35
**Ficus benjamina*	15.00	0.05	1.025	11.89	40
Ficus cunia	5.00	0.20	0.267	3.27	65
Ficus hirta	10.00	0.10	0.258	5.55	90
Ficus nemoralis	25.00	0.04	0.898	15.29	135
**Ficus roxburghii*	60.00	0.03	3.257	35.51	135
Leucosceptrum canum	15.00	0.05	0.484	9.97	110
Litsaea citrata	10.00	0.11	0.379	5.98	—
Litsaea polyantha	14.00	0.05	0.406	9.68	145
Macaranga pustulata	12.00	0.10	0.459	6.27	—
Salmalia malabarica	—	—	—	—	30
Schima wallichii	21.00	0.09	1.269	12.49	465
Spondias axillaris	60.00	0.02	3.070	36.13	245
Toona ciliata	5.00	0.20	0.438	3.87	10
Zanthoxylum budrunga	—	—	—	—	40
Unidentified (Kamlo)	50.00	0.09	0.816	19.83	—
Unidentified (Mahony)	15.00	0.10	0.298	6.70	—
Stand VI: Yuksam					
Acer campbellii	—	—	—	—	150
Castanopsis indica	290.00	0.03	24.495	162.83	390
Engelhardtia spicata	5.00	0.20	3.417	10.25	150
Eriolobus indica	50.00	0.07	9.675	45.27	65
Eurya acuminata	11.00	0.10	0.796	8.80	100
Juglans regia	9.00	0.11	6.026	18.20	5
Lyonia ovalifolia	26.00	0.17	1.667	16.50	25
Macaranga pustulata	6.00	0.19	0.913	6.85	—
Machilus edulis	10.00	0.10	4.211	15.41	70
Measa chisia	—	—	—	—	501
Prunus cerasoides	3.00	0.10	0.028	3.21	—
Rhus succedanea	5.00	0.12	0.073	5.47	—
Symplocos sumuntia	—	—	—	—	80
Symplocos theifolia	—	—	—	—	80
Viburnum sp.	—	—	—	—	375
Walsura tubulata	3.00	0.17	0.315	4.25	55
Unidentified	2.00	0.21	0.024	2.96	—
Unidentified (3 species)	—	—	—	—	740

TABLE 3—(continued)

Species[a]	Density (ha^{-1})	A/F[b] ratio	Total basal area (m^2ha^{-1})	IVI[c]	Regeneration (ha^{-1})[d]
Stand VII: Pangthang					
Acer campbellii	—	—	—	—	160
Albizia procera	—	—	—	—	50
Alnus nepalensis	35.00	0.06	2.440	25.08	—
Beilschmiedia roxburghiana	10.00	0.40	6.759	22.48	—
Castanopsis tribuloides	10.00	0.10	0.087	6.54	20
Elaeocarpus sikkimensis	15.00	0.05	1.050	13.97	10
Endospermum chinensis	35.00	0.04	1.780	25.06	—
Eurya acuminata	75.00	0.02	5.290	54.42	260
**Evodia fraxinifolia*	5.00	0.20	0.064	3.31	10
Machilus edulis	25.00	0.04	12.830	49.75	333
Machilus gammiena	—	—	—	—	25
Machilus odoratissima	5.00	0.20	1.317	6.63	—
Michelia excelsa	—	—	—	—	50
Michelia lanuginosa	5.00	0.20	0.724	5.07	10
**Prunus nepalensis*	5.00	0.20	2.178	8.92	5
Rhus succedanea	5.00	0.20	0.397	4.19	—
Symplocos sumuntia	15.00	0.15	0.880	10.08	170
Symplocos theifolia	65.00	0.02	1.530	43.31	1375
Viburnum cordifolium	40.00	0.06	0.421	21.17	410
Unidentified (5 species)	—	—	—	—	250
Stand VIII: Tendong-Tifintop					
Acer campbellii	10.00	0.10	4.970	4.21	25
Acer oblongum	—	—	—	—	205
Beilschmiedia roxburghiana	15.00	0.07	2.800	8.04	20
Betula cylindrostachys	10.00	0.10	0.270	3.58	—
**Castanopsis tribuloides*	115.00	0.03	12.300	41.95	70
**Celtis tetrandra*	15.00	0.07	0.466	5.47	—
**Cinnamomum impressinervium*	10.00	0.10	0.644	4.03	20
Echinocarpus dasycarpus	5.00	0.20	0.190	1.87	—
Elaeocarpus sikkimensis	5.00	0.10	1.600	4.35	—
Endospermum chinense	5.00	0.60	0.540	3.62	—
Engelhardtia spicata	10.00	0.10	0.840	4.21	35
Eurya acuminata	15.00	0.07	0.820	5.86	505
**Evodia fraxinifolia*	15.00	0.07	0.680	5.71	15
**Ilex sikkimensis*	25.00	0.11	0.690	7.12	—
Juglans regia	—	—	—	—	15
Leucosceptrum canum	—	—	—	—	410
Litsaea oblonga	5.00	0.20	0.150	1.82	—
Lyonia ovalifolia	55.00	0.17	5.100	18.96	—
Macaranga pustulata	15.00	0.15	0.263	4.28	—
Machilus edulis	55.00	0.04	5.58	20.51	—
Machilus gammieana	15.00	0.01	3.600	8.91	—
Measa chisia	—	—	—	—	65
Michelia excelsa	15.00	0.15	1.290	5.41	40
**Myrica sapida*	5.00	0.10	0.150	1.82	—
Nyssa sessiliflora	10.00	0.20	0.710	3.13	—
Quercus fenestrata	25.00	0.06	1.890	9.39	—
Quercus lamellosa	80.00	0.03	19.700	43.27	25

TABLE 3—(continued)

Species[a]	Density (ha^{-1})	A/F[b] ratio	Total basal area (m^2ha^{-1})	IVI[c]	Regeneration (ha^{-1})[d]
Quercus sp.	40.00	0.10	6.400	16.40	—
**Rhododendron arboreum*	45.00	0.05	9.590	22.50	15
Symplocos sumuntia	—	—	—	—	600
Symplocos theifolia	35.00	0.06	1.200	10.99	1205
Walsura tubulata	10.00	0.10	0.180	3.52	10
Unidentified (2 species)	50.00	0.20	8.660	24.18	—
Unidentified (5 species)	—	—	—	—	1420

[a] Extensively used wild edible species at each stand are shown in bold italics, while minor ones are indicated with an asterisk.
[b] A/F = Abundance/Frequency.
[c] IVI = Importance Value Index (sum total of Relative Frequency + Relative Density + Relative Dominance).
[d] NR = data not recorded.

Eriolobus indica, which is a short tree, individuals of 55.0 to 130.0 cm cbh were harvested to measure fruit yield. The fruit yield varied from 6.56 to 58.0 kg per tree for different girth class size trees. An individual tree had 94 to 1850 fruits per plant. Fruit yield of *Machilus edulis* varied from 5.16 to 75.00 kg per tree for a girth class of 135 to 410 cm, respectively. For this species the per-tree fruit yield increased up to a girth class of 265 cm and thereafter it decreased. Tree individuals are big and attain a height of up to 30 m. Since it is difficult to reach fruit in at the ends of high branches, fruit collectors lop branches to harvest the fruits. In the case of *Spondias axillaris,* trees of 56- to 251-cm girth classes produced 5.60 to 107.00 kg of fruit per tree, respectively. For *Baccaurea sapida,* a total of 2112 to 17,940 fruits have been harvested for trees in the 34- to 70-cm girth class sizes, and productivity varied from 21.50 to 156.00 kg per tree. For *Elaeagnus latifolia,* individuals of 39 cm to 123 cm cbh were harvested to measure their fruit yield, which varied from 9 to 155 kg per plant for different girth classes. Field observations revealed that fruit collectors lopped branches of big trees to harvest fruit, which resulted in low fruit yields the following season.

Marketing.—Among the three markets studied, Gangtok received all six species in high volume. Singtam received *Diploknema butyracea, Elaeagnus latifolia,* and *Spondias axillaris,* while Namchi received *D. butyracea, Machilus edulis,* and *S. axillaris.* Among all the species, *S. axillaris* was sold in maximum quantity, followed by *M. edulis* and *E. latifolia* (Figure 2). The gross income to vendors was also higher from *S. axillaris,* followed by *M. edulis.* The value of the total quantity sold and gross income from the six species presented in this investigation is probably on low side, as many retailers also sell the fruits in small quantities outside the main market directly sold to individuals or households.

Economics of Production of Pilot Stands.—To illustrate the value of cultivating forest trees, potential yields and economic returns of fruit-growing under a variety of conditions were estimated based on observations of wild-growing trees. The total number of trees for each species that could be accommodated per hectare plan-

TABLE 4.—Period of active and cessation of growth of leaf, flower and fruit formation in six selected wild edible species in the Sikkim Himalaya.

	Leaf		Flowers		Fruit	
Wild edible species	Active growth period	Cessation of growth	Flower bud opening	Flowering ends	Fruit formation	Maturation/ dispersal
Baccaurea sapida	Mar I–April II	Apr III	Feb IV–Apr I	Apr II	Apr III	Jul–Aug
Diploknema butyracea	Jun I–Jun II	Jun IV	Nov–Dec	Jan IV	Feb–Mar	Apr–May
Elaeagnus latifolia	Year-round	—	Dec–Jan III	Jan IV	Feb–Mar	Apr–May
Eriolobus indica	Apr–May	Jul	Mar III–Apr II	Apr III	May	Oct–Nov
Machilus edulis	Year-round	—	Mar–Apr	May	May–Jun	Dec
Spondias axillaris	Apr IV–May IV	Jun IV	May–Jun	Jun	Jun	Sep–Nov

I, II, III and IV refer to the first, second, third, and fourth weeks of the respective month.

TABLE 5.—Mean tree characteristics and fruit yield for six selected wild edible species in the Sikkim Himalaya.

			Tree spread (m)				
Species	Girth at breast height (cm)	Tree height (m)	N–S	E–W	No. of fruit per branch	Total no. of fruits per plant	Total fruit yield/tree
Baccaurea sapida	54.36 ± 6.00	6.40 ± 0.54	5.05 ± 0.37	5.15 ± 0.38	113 ± 14	8265 ± 2060	72.44 ± 16.80
Diploknema butyracea	133.19 ± 9.70	14.37 ± 3.80	8.26 ± 0.82	8.72 ± 0.52	296 ± 74	6538 ± 1991	52.12 ± 16.01
*Elaeagnus latifolia**	94.00 ± 11.40	10.94 ± 1.31	—	—	69 ± 10	4860 ± 1403	59.68 ± 16.85
Eriolobus indica	91.12 ± 9.46	8.04 ± 0.38	5.84 ± 1.00	5.45 ± 0.88	43 ± 9	888 ± 125	28.27 ± 7.63
Machilus edulis	243.89 ± 28.84	21.05 ± 5.55	8.38 ± 1.81	8.26 ± 1.83	37 ± 10	4066 ± 315	67.18 ± 7.35
Spondias axillaris	162.81 ± 21.14	16.50 ± 2.61	13.31 ± 2.27	10.53 ± 2.13	195 ± 61	5317 ± 2229	57.36 ± 22.67

* Liana (woody climber).

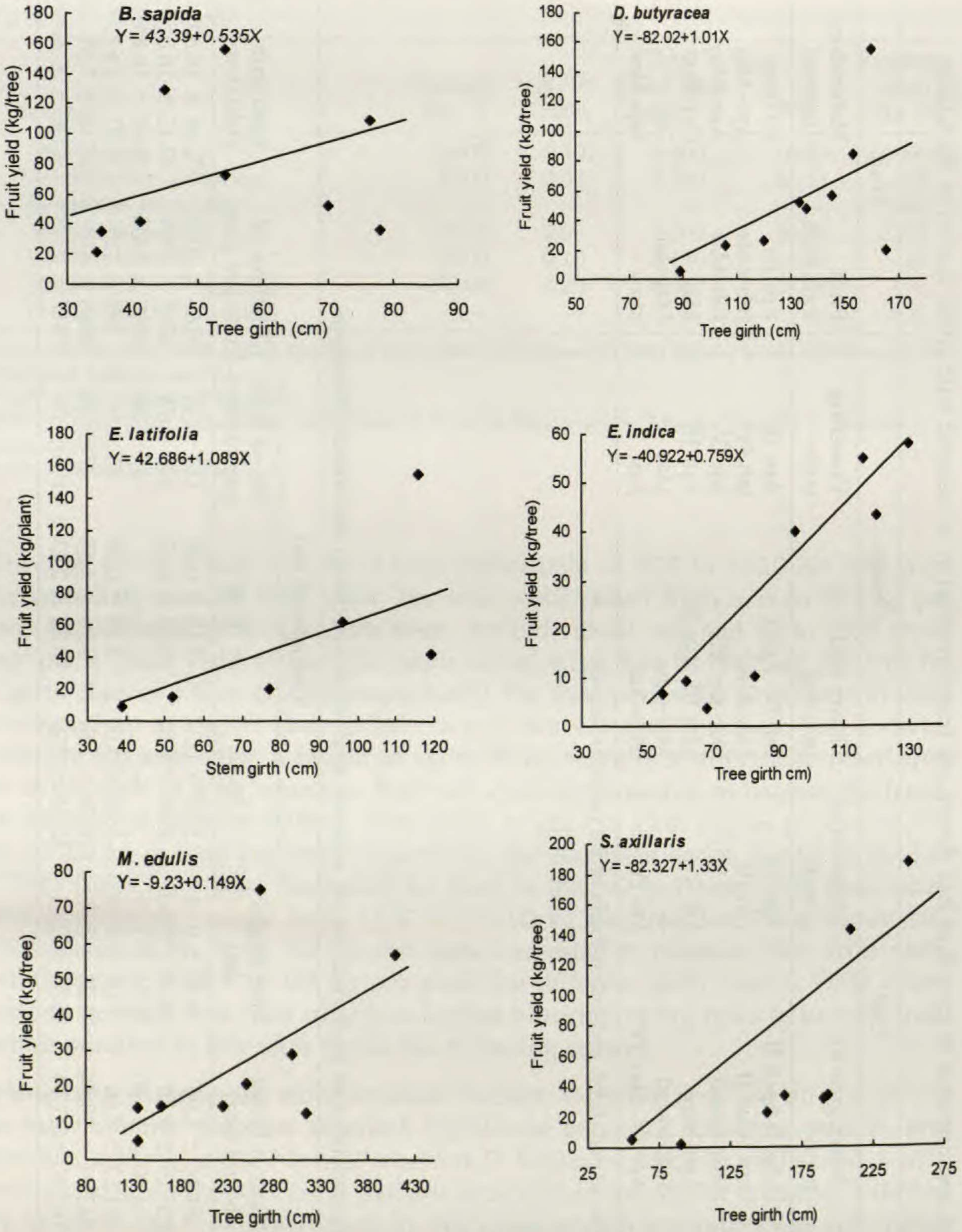

FIGURE 1.—Plant girth (cm) and fruit yield (kg/plant) of different wild edible species in the Sikkim Himalaya. In regression equation, Y is fruit yield and X is tree girth. R values: *B. sapida* (0.192), *D. butyracea* (0.282), *E. latifolia* (0.411), *E. indica* (0.871), *M. edulis* (0.262), *S. axillaris* (0.545).

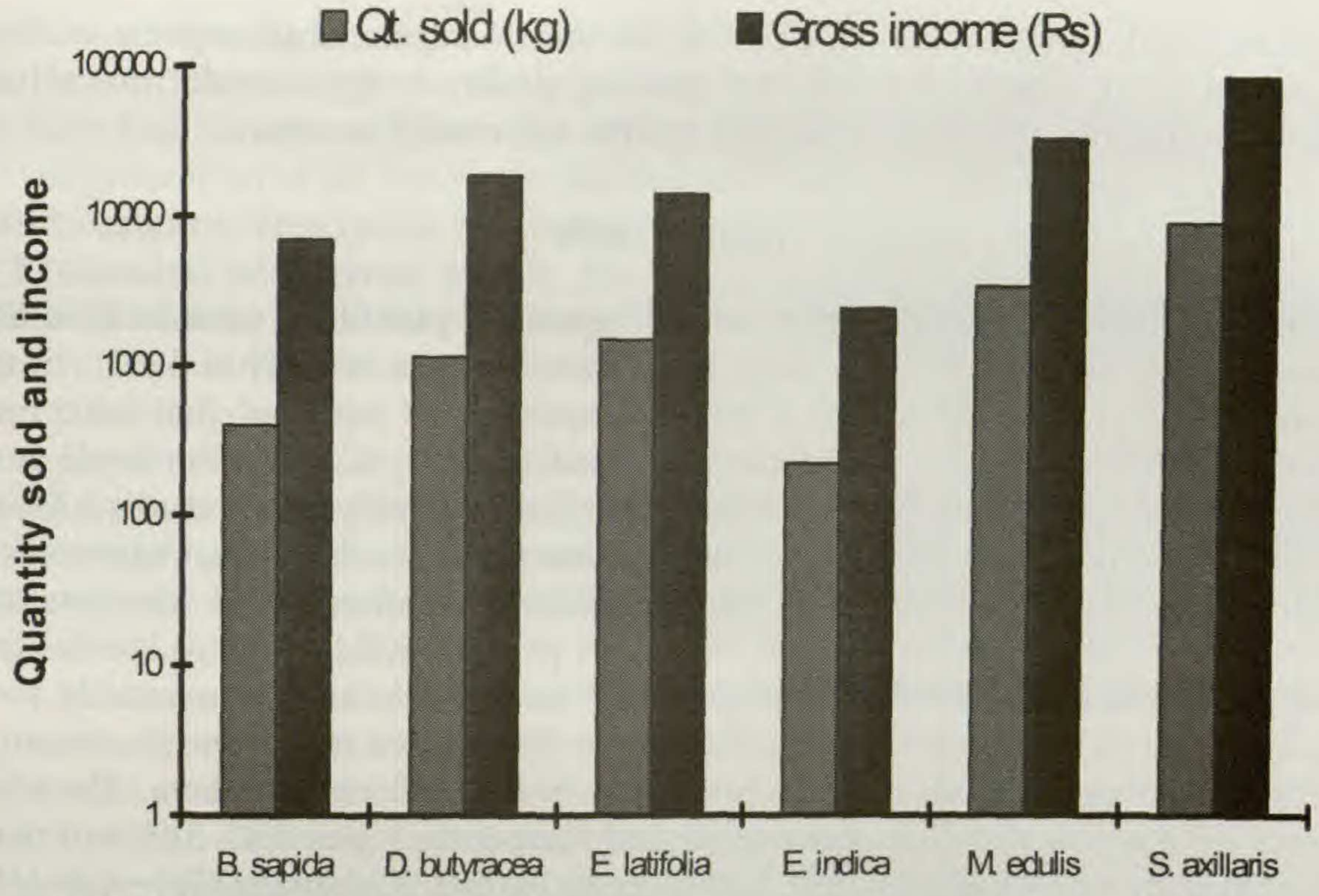

FIGURE 2.—Marketing of the six selected species and gross income from selling the fruits.

tation is calculated based on tree-spread (total canopy area covered by each species) (Table 6). *Spondias axillaris,* which has the largest area under each individual tree due to its broad canopy, could accommodate a planting of only about 180 mature tree ha^{-1}. In contrast, *Baccaurea sapida* has the smallest area covered by each tree, so nearly 450 trees ha^{-1} could easily be accommodated in a pure stand. In principle, *B. sapida* would give the highest income among all the species if grown in a pure stand. (Note that monocropping of trees that evolved in a diverse forest might not be the best way to cultivate them, but at this point in our research it is important to present alternatives to cutting down forest stands; see Bandeira et al. 2002.) *Machilus edulis, S. axillaris,* and *Diploknema butyracea* may be grown in

TABLE 6.—Expected economics of production of pilot stands of each individual wild edible species.

Species	Mean tree spread (m^2)	Expected mature tree density in a pure plantation (trees ha^{-1})	Expected annual fruit yield* (tons)	Retail prices/kg	Gross income (Rs.)
Baccaurea sapida	20.40	450	32.60	10.00	325,980
Diploknema butyracea	36.60	275	14.33	8.00	114,664
Elaeagnus latifolia	44.50	225	13.43	8.00	107,424
Eriolobus indica	25.00	400	11.31	8.00	90,464
Machilus edulis	54.40	185	12.43	12.00	149,140
Spondias axillaris	60.00	170	9.75	10.00	97,512

* Calculated on the basis of 75% trees bearing fruits; 1US$ = Rs. 47.

wasteland and can provide substantial income to farmers; all aspects of fruit processing, from simple cleaning and grading quality to the manufacture of juices, jams and jellies can add value and double a farmer's income.

DISCUSSION

In the Himalaya a large variety of wild growing plants are used as food and some of them are exploited in large quantities (Samant and Dhar 1997). In the Sikkim Himalaya a total of 190 wild plant species are reported that have food value, of which 49 species are commonly used (Sundriyal 1999; Sundriyal et al. 1998). Wild woody plants that produce edible fruits are very rarely studied. Given the lack of information about their natural associations, densities, regeneration, phenology and fruit yields, they do not receive the attention of foresters and researchers in afforestation (Martin 1995). Six popular wild-growing species that produce edible fruits and have the potential to be exploited commercially were studied in detail to obtain information about their place in the forest structure, phenology, fruit yield, and future prospects in the Sikkim Himalaya. The eight forests we studied all fall in subtropical and temperate zones with different management regimes—Reserve Forest, Community Forests, Khasmahal Forest and Private Forest. The Reserve Forests are managed by the Forest Department, and generally are devoid of any pressure except for the collection of a few non-timber forest products. The management of Community Forests is dependent on the entire village community. After villagers harvest a forest resource, they do not return to the same place until the plants have had time to recover. In Khasmahal Forest, however, multidimensional pressure—timber, fuel, fodder, and NTFP collection—result in low stand density. The Private Forests are maintained according to individual family need. Species selection is based partly on economic value, mainly as fuel, fodder, and food; density of such stands is also low.

The total stand species diversity and density was highest in the Reserve Forests, followed by the Community Forests, and lowest in the Khasmahal and Private Forests. Though the total number of wild edible species was highest in Reserve Forest stands, these species contributed just a quarter of the total stand density. Contribution of wild edible species to total stand density was >35% in Private Forest and >25% in Community Forest, which suggests the villagers actively maintain preferred species. In contrast, the contribution of wild edible species to total stand density in the Khasmahal Forest was 15%, which suggests people are less concerned with sustainable use of land they do not own.

The six species we studied were in high demand for their fruits. With the exception of *Machilus edulis* and *Spondias axillaris,* which are upper canopy species, they are middle-story species in the forest stands. Though the collective contribution of all wild edible species to total stand density, basal cover, and IVI was significant, an individual wild edible plant species in each stand contributes much less (<7%), which shows that all these species are associated species in the forest stand and such species are very important for maintaining forest diversity (see Phillips 1993). A few wild edible plants are cut down or otherwise stressed despite the economic value of their fruits. For example, *Diploknema butyracea* is also exploited heavily for fodder as well as for its fruits. Similarly, the wood of *B.*

sapida is also considered good fuel, while *M. edulis* and *S. axillaris* are exploited for timber. The pressure on the wild populations of these species is exacerbated by their low density and low rates of regeneration.

Regeneration of all species in the Reserve Forest was better than in any other forest category. This could be attributed to substantial fuel and fodder removal in Khasmahal and Private forests. However, the percentage contribution of wild edible species to total stand regeneration was much higher in Private and Community Forests (35–65%) than in the Reserve Forest. To some extent, villagers manipulate regeneration by uprooting certain undesirable species and promoting wild plants of food and other economic value in Private and Community forests. The six selected wild edible species showed poor regeneration in comparison to many other tree species in their respective forest stands, however. Local people collect fodder from the forest floor. In the process, they unknowingly collect seedlings of wild edible species.

Leaves are central to the adaptation of a plant for growth and competitive success, so it is important to understand the periodic progression of leaf growth for species management (Negi and Singh 1992). November through March is the period of leaf shedding for most of the tree species and 80% of the genera complete their bud burst by April in the Sikkim Himalaya (Sundriyal, unpublished data). Generally most wild edible species shed their leaves during winter months. Flowering of the various studied species ends before the monsoon rains. *Diplokнema butyracea* and *Eleagnus latifolia* took the least time from fruit formation to maturation, *Baccaurea sapida* and *Spondias axillaris* took an intermediate time, while *Eriolobus indica* and *Machilus edulis* matured most slowly. It can be concluded that generally fruit development and maturation take longer for species with bigger fruit. Fruit maturation and dispersal completed before the rains for *D. butyracea* and *E. latifolia,* during the rains for *B. sapida,* and after the rains and before winter for *S. axillaris, E. indica,* and *M. edulis.* The time of fruit maturation is directly linked with the seed germination. For example, fruit that matures after the rains and during the winter months have a longer dormancy and viability period than those mature during the rains in the six selected species (Sundriyal and Sundriyal 2001b).

Per-tree fruit yield is good enough to provide attractive opportunities for the villagers to collect them. However, fruit collection is highly erratic, because it is not regulated by the community. Often, large tree branches are lopped, because income depends on the amount of fruit collected as quickly and easily as possible. Such practices may lead to depletion of many species from forest areas in years to come. Where forest cover is dense and human population levels are low, forests maintain a good diversity of species, and wild edible fruit trees can yield good harvests. The wild edible species play an important role in enhancing nutrition, particularly for rural populations who can not afford to buy the fruit sold in the market (Sundriyal and Sundriyal 2001a).

Plant collectors visit forest stands to collect fruits of the six species that are the focus of this study. If the desired quantity of fruit is not available, they will collect diverse species of economic value to justify their labor expenditure. In addition to the six studied species, the plant collectors harvest fruits of *Castanopsis tribuloides, Juglans regia, Elaeocarpus sikkimensis, Mangifera sylvatica,* young shoots of

various bamboo species, tubers of *Dioscorea, Diplazium,* and *Agaricus* species in large quantities (Sundriyal 1999).

Collection of wild plants plays a major role in the rural economy because farmers sell these plants in the nearby markets. For many poor people, selling wild plants is their only source of income. Generally, most of the wild edible plants are available for a short period, and due to their perishable nature they are sold at low prices (Sundriyal et al. 1998). Fortunately, all species studied in this investigation have high potential for value addition (Sundriyal 1999), as is being demonstrated for some wild plants in the other parts of the Himalaya (Dhyani and Khali 1993; Maikhuri et al. 1994). Cultivation of the six most desirable types would therefore reduce pressure on all forest plants.

Interviews with the villagers revealed that they are willing to raise all the selected species in their farms. The seeds of these wild edible species show good germination rates when they are raised in a nursery (Sundriyal and Sundriyal 2001b). Unfortunately they are not yet included in the plantation schemes undertaken by any state government or department. Obtaining a supply of such seedlings is a real problem if these species are to be grown by farmers. There is a need to ensure a supply of quality seedlings to farmers, which will have significant benefits for the adoption of these species in agroforestry systems.

Future Prospects.—Disturbance has become widespread in most of the forests in the Sikkim Himalaya. Therefore, information on species composition, growth, regeneration, other phenological characteristics, and sustainable harvest levels is important if we are to rejuvenate the severely stressed forests and individual trees. This is particularly critical for plants of low commercial value but that are nevertheless very useful to local people. In wild plant communities, sustained growth of all species in the presence of older plants is necessary to maintain the health of the stand (Singh and Singh 1992). A large number of people are supported on wild food resources in remote areas, and population growth will lead to a greater demand for food and other necessities in near future. In some forest stands, the density and regeneration of the species discussed in this report is low and conservation efforts should emphasize these species. As wild food plants are exploited mainly by the local plant collectors, they receive little attention from foresters; therefore, the natural populations are quickly getting depleted. These species are crucial for maintaining diversity of the stands (FAO 1985; Herzog et al. 1998). The wild edible plants may bring sufficient returns if grown in the traditional agricultural system in hilly areas. Each of the six species yields a good quantity of fruits and thus provides high economic returns if properly maintained. An assessment of the economics of the pilot stands for the six selected species reveals that all can produce good returns, especially *Baccaurea sapida.* Furthermore, a simple value addition could enhance the benefits. The wild edible species are also used for fruit, fodder, fuel, and timber collection. Therefore, cultivation of these species as part of an agroforestry program perhaps will also contribute to the conservation of genetic resources. If properly planted and cultivated some of these species can replace staple or commercial fruits, thereby contributing handsomely to the economy of the subsistence farmers in the mountains.

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